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Reuse of Legacy Data for Vehicle Support within the US Army

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Abstract

The US Army Tank Automotive and Armaments Command (TACOM) supports combat and tactical vehicles for the Department of Defense. It is becoming increasingly important for the Army to acquire spare parts for existing vehicles cost effectively. New vehicle systems such as the Future Combat System must be developed in shorter time frames incorporating the very latest technologies available and using the latest modeling and simulation tools.

Reusing valuable legacy data is one approach to reducing product lifecycle costs. However, legacy Army data exists in several heterogeneous formats such as paper and Mylar drawings, 2D vector drawings and some 3D CAD models. This paper discusses the issues involved with working in a heterogeneous product data environment and potential solutions to the problem. The objective is to eventually acquire data in an intelligent 3D parametric model format, convert legacy data where practical and store the information in a Product Data Management system to reap the benefits of modeling and simulation throughout the organization.

Introduction

The average age of the US Army's combat vehicle fleet is between 35-40 years old. Tanks such as the Abrams and Bradley are the core of the Army's fleet. Many of these vehicles are being modified and retrofitted with advanced weaponry and instrumentation to meet the challenges of war fighting today. The US Army Tank Automotive and Armaments Command (TACOM) manages and supports these product lines through their lifecycle. The Tank Automotive Research Development and Engineering Center (TARDEC), now under the Research Development and Engineering Command (RDECOM), researches, develops and leverages advanced technologies to provide engineering support for these product lines to ensure system readiness throughout the lifecycle.

With the deployment of the Army's new Future Combat System (FCS) not slated till 2010, it is becoming increasingly important to sustain these product lines for a longer period of time. As a matter of fact, these vehicles are no longer referred to as legacy fleet, but as the current fleet. Being able to procure spare parts quickly and inexpensively for these vehicles is one activity that

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can be modernized with technology. Hence there is a need to convert legacy drawings to intelligent 3D models.

Need to move to 3D

Product data used to design combat vehicle systems are largely paper-based. This poses a bottleneck to electronic procurement activities since it is cumbersome to transfer non-electronic data to part suppliers in the acquisition process. Furthermore, suppliers cannot directly use the paper-based data for automated manufacturing that requires data to be present in intelligent 3D formats. The newer Numerical Control (NC) machines require CAD data in 3D formats to take advantage of automated manufacturing methods. Hence there is a need to convert these legacy drawings to digital formats to provide improved logistic support.

Whether parts are being redesigned or newly designed, legacy data in some form or another is often used to start the design process. However, today's advanced feature-based 3D CAD systems cannot directly use 2D legacy data. The designers have to go through a difficult process of first converting 2D drawings to nominal 3D models before they can be reused in the 3D CAD system.

In many corporations across the world, the US Army included, there is a need to visualize product designs for non-engineering use. These could either be for procurement solicitation activities in the government or for marketing and sales in private industry. For a large part, these users are not CAD engineers who can understand 2D drawings. If these designs were available to them as viewable 3D models, CAD viewers can be to view the product data more easily. The alternative is to pan and zoom on a raster 2D drawing.

TACOM currently owns over a million legacy drawings as scanned images. Of these, about 20,000 have been converted to 2D CAD files as part of the DoD's Automated Document Conversion System (ADCS) program. The Program Manager's Office of the Family of Medium Tactical Vehicles (FMTV) has converted about 2000 drawings to parametric 3D models in Pro/ENGINEER format. The time is right for TACOM to evaluate automated software for converting legacy 2D drawings to intelligent 3D models.

Issues with legacy data

The process or converting scanned raster images to 2D CAD vector files is known as vectorization. The quality of the vector files is dependent on the quality of the input scanned images and the vectorization process. Today several automated and semi-automated software are available for raster to vector conversion. Some of these include VP Studio, GTX Image CAD, eXtract and TracTrix. Some of the errors encountered in the vectorization process are duplicate and overlapping edges, disconnected edges, breakup of entities and incorrect scale factors and skewed views.

There are several issues with regards to the input data. If the input data is a scanned raster image, it is important to make sure that the document has been scanned at the right resolution. If this is not done, the resulting images have noise speckles that can make it hard to vectorize the

drawings. The problems are worse if the hardcopy drawings are of poor quality to start with. Paper drawings usually degenerate over time and coffee stains and ink spills are common in many paper drawings. Because of the limitation of the scanners available today, some extra-large sized drawings cannot be scanned into one single image file. They have to be split into multiple sheets to accommodate the large sizes. These are problems when the file needs to be converted to a CAD vector format.

Conversion Decision Factors

Given the nature and variety of vehicle system components not all drawings should be converted to 3D. TACOM created a decision scale to help users decide which drawings would provide a return on investment if converted to 3D.
Some of these factors are:

1. System density - how many of these systems are being used and is their use considered high
2. Likelihood of future production quantities being procured
3. Estimated remaining lifecycle
4. Interface with other systems
5. Mechanical content – benefits of converting mechanical drawings are more than electrical wiring drawings
6. Potential for design changes
7. Technical Data Package availability and rights
8. Quality of the data

When a decision has been made to convert a 2D drawing to 3D, the *TACOM 3D Modeling Best Practices* document is used as the standard. 3D models created must be fully parametric feature-based 3D models. These intelligent models are designed as features such as protrusions, cuts, holes, cuts, fillets and chamfers along with parametric relationships between the features. Parametric models are easily editable for redesign or incorporating engineering change orders. Although Pro/ENGINEER is the recommended 3D CAD system, other CAD systems can still be used if there is a need to do so. The standards document also states that 3D models need to have associative 2D drawings with dimensioning consistent with the original 2D drawing. Finally, the standards document also has guidelines on how to specify material and surface finish, layers, colors, notes, file names, etc.

Conversion Methodology

The methodology used to perform the conversions is illustrated in Figure 1 below. Raster images can be converted to vector 2D CAD drawings using a raster to vector conversion software. The 2D CAD drawing can then be converted to a 3D model in Pro/ENGINEER using a commercial off the shelf software. The 3D model is stored in a product Data Management (PDM) system from where it can be transferred to suppliers as technical data packages (TDP).

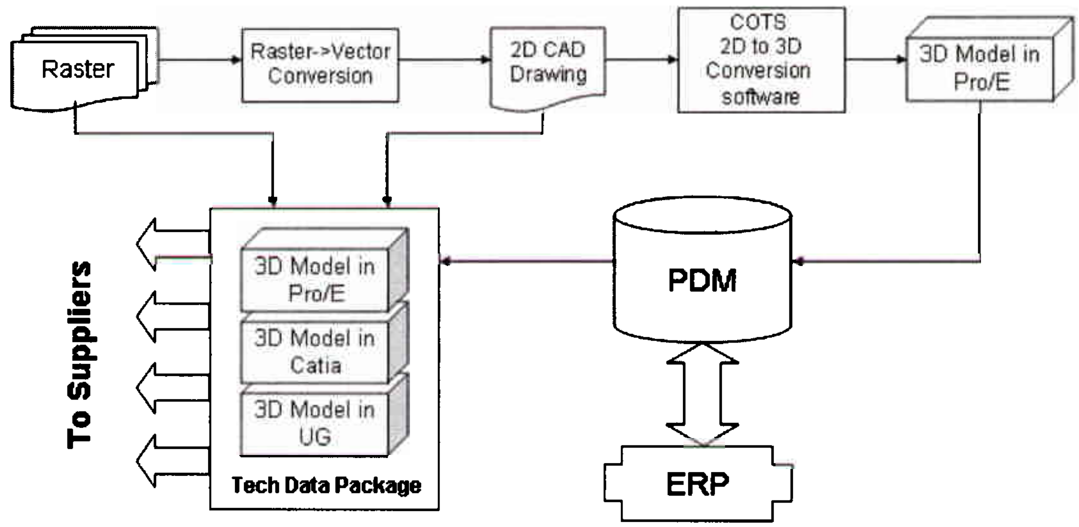

Figure 1. Conversion methodology

A more detailed methodology proposed to convert 2D CAD drawings to 3D models is shown in Figure 2. One of the COTS 2D to 3D conversion software that TACOM is evaluating is called FlexiDesign. This automated software can generate a parametric 3D model in Pro/ENGINEER format through an intermediate Universal Feature Object (UFO) format. The 2D CAD drawing is first split into graphics (describing the views) and text (describing the notes). The orthographic views describing the part are sent to FlexiDesign that creates a 3D model in a UFO format. A UFO-Pro/ENGINEER plug-in can then be used to generate a parametric 3D model in Pro/ENGINEER format. This model can then be back projected to generate an associative 2D drawing. The notes from the original CAD drawing are merged into the associative 2D drawing to develop a detailed 2D drawing that is bi-directionally associative with the 3D model.

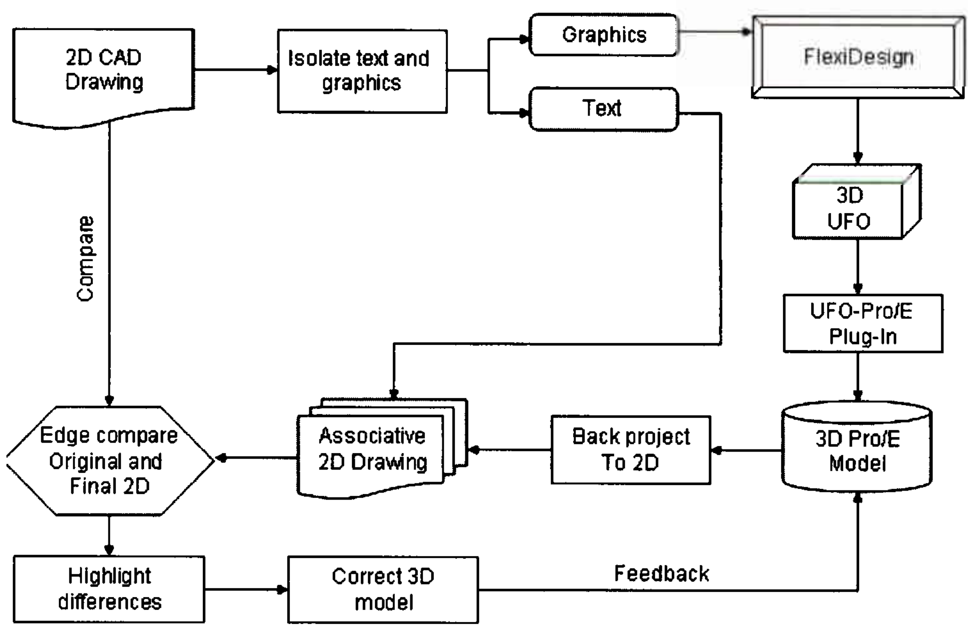

Figure 2. Detailed 2D to 3D Conversion Process

The back projected 2D drawing can be overlaid on top of the original 2D drawing and an automated edge to edge comparison can be performed, to determine the quality of the converted drawing,. All the mismatched edges (missing or spurious) are highlighted to indicate the differences from the original drawing. This information can then be provided as feedback to the user to make any modifications to the 3D model. The final Pro/ENGINEER 3D model can be stored in a PDM such as Pro/INTRALINK.

A 3D model generated from this conversion process is shown in Figure 3. A sample 2D drawing of a relay-circuit breaker box bracket from an M981 (M113 Family of Vehicles) was converted to a parametric 3D model in Pro/ENGINEER format using the above process. The part was successfully converted to a 3D model in about 20 minutes using FlexiDesign with little or no human intervention assuming that a 2D CAD drawing is available.

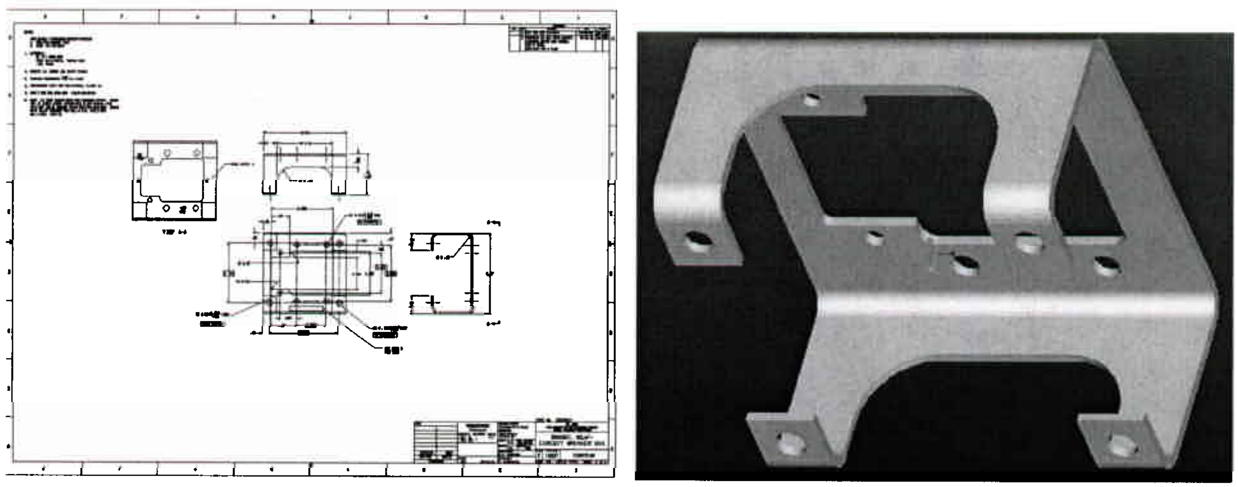

Figure 3. Sample input 2D drawing and output 3D model

Potential Benefits

Although the benefits of moving to 3D have been widely accepted, the potential benefits of an automated process to migrate the legacy drawings to 3D are much higher. Based on pilot conversions that TACOM performed using FlexiDesign, automated conversions have been about 4-5 times faster than manual conversions. Furthermore, the automated conversions do not require engineers or 3D modeling experts that are typically needed to perform manual conversions. This also reduces the cost of conversions considerably. Using the UFO as the intermediate intelligent neutral format, it is possible to generate 3D models in a variety of other CAD systems such as CATIA, SolidWorks and Unigraphics thereby providing suppliers with models in formats that they can directly read. This in turn can reduce the cost of procuring manufactured parts because the supplier does not need to regenerate the design in their CAD system. Finally, an ability to use automated software allows TACOM to perform conversions in-house on an as-needed basis.

Conclusions

The US Army TACOM, just like private industry, recognizes the need to move to 3D design to take advantage of the cost and time savings that other industries like the auto industry have seen. Cost saving automated software such as FlexiDesign is now becoming available and affordable today. Even though automated software have some limitations on the classes and complexity of parts they can handle, they are still productivity improvement tools over any direct manual conversions in the 3D CAD system.

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